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AUTHOR Olsen, James B.; And Others
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ABSTRACT

A total of 169 college students participated in two experiments investigating the effects of eight instructional sequences and the presence of a heuristic rule in the teaching of four coordinate concepts: trochaic, iambic, dactylic, and anapestic poetic meters. A four-factor experimental design was used: pure simultaneous or sequential presentation of the four concepts; presence or absence of a mixed instructional sequence providing a rule and an example; presence or absence of practice items; and presence or absence of a heuristic rule for classifying the concepts. A classification test provided a measure of the effectiveness of the instructional treatments. Measures of instructional time and test time provided data on the efficiency of the treatments. Results indicated that the optimum treatment in these experiments was simultaneous-mixed-heuristic, which required less instructional time and less test time, and which led to higher student posttest scores. (Author/AA)

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Effects of Simultaneous or Sequential Sequences and the Presence of a Heuristic Rule in Teaching Coordinate Concepts

James B. Olsen, Charles M. Reigeluth, and M. David Merrill

Brigham Young University

ABSTRACT

This paper investigates the effects of eight instructional sequences and the presence of a heuristic rule in the teaching of four coordinate concepts: trochaic, iambic, dactylic, and anapestic poetic meters. A factorial design compares the effects of a pure simultaneous or sequential presentation of the four concepts (first factor), presence or absence of a mixed instructional sequence which provides an integrated rule and example combination (second factor), the presence or absence of practice items with correct answer feedback (third factor), and the presence or absence of a heuristic rule for classifying the concepts (fourth factor). A correct classification test provided a measure of the effectiveness of the instructional treatments. Measures of instructional time and test time provided data on the efficiency of the different treatments.

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Much of the research in concept learning has focused on the teaching of singular, isolated concepts. However, the majority of classroom concepts do not exist as isolated entities, but are part of an interrelated network of concepts characterized by superordinate, subordinate, or coordinate relationships (Klausmeier, Ghatala, and Frayer, 1974, Tiemann and Markle, 1973, Merrill and Tennyson, 1976, Note 1). Coordinate concepts, such as trochaic, iambic, dactylic and, anapestic meters, are concepts which are on the same level of generality and are subordinate to the same superordinate concept such as poetic foot (see Figure 1). In this paper, two experiments are reported which investigate variables in teaching four coordinate concepts.

Primary Presentation Forms

Merrill and Wood (1975, Note 2) indicate that a segment of instruction may consist of three primary presentation forms: expository generalities (rules), expository instances (examples) and inquisitory instances (practice items with some type of feedback). A review of the research on instructional strategies (Merrill, Olsen, and Coldeway, 1976) identified six research studies (Anderson and Kulhavy, 1972; Deno, Jenkins and Marsey, 1971; Guthrie and Baldwin, 1970; Johnson, 1968; Klausmeier and Feldman, 1975; and Merrill and Tennyson, 1976, Note 3) which indicate that acquisition of a single concept is facilitated if the instruction consists of all three primary presentation forms. No studies were found which contradicted this hypothesis.

Sequences of Primary Presentation Forms

When we extend this principle to teaching several coordinate concepts the question naturally arises, how should the primary presentation forms be sequenced? The experiments investigated the following types of instructional sequences.

Pure Sequences

The simultaneous sequence presents the rules for all four coordinate concepts, then examples of all four concepts, and finally practice items for the four coordinate concepts (see Figure 2).

The sequential sequence presents the rule, examples, and practice items for one coordinate concept, then the rule, examples, and practice items for the second coordinate concept, and so forth for all four concepts (see Figure 2).

Mixed Sequences

To permit students to see the relationship between the rule and two examples, a mixed instructional sequence was developed. The mixed simultaneous sequence presents, on one page, the four rules each followed by two examples of the rule.

The mixed sequential sequence presents a rule and two examples combination for one concept. Further examples and practice items are presented for the first concept. Then a rule and two example combination is presented for the second concept, followed by further examples and practice items for the second concept, and so forth for all four concepts (see Figure 2).

Practice

The third factor in these experiments was the presence or absence of practice items. The practice items asked the student to classify unencountered poetic lines according to the type of meter. Correct answer feedback was provided on the following page.

Heuristic

The fourth factor was the presence or absence of a heuristic rule, which told the student to try saying the verse in each of the four types of meter and choose the one which seems to fit the verse the best.

Dependent Variables

The dependent variables in the experiments were:

1. Effectiveness of the instruction, which was measured on a posttest by the number of correct classifications of unencountered instances of the four coordinate concepts.
2. Efficiency of the instruction, which had two measures: (a) instructional time and (b) test time.

Hypotheses

Hypothesis 1: Instruction in coordinate concepts would be more effective if the concepts are presented simultaneously rather than sequentially.

Hypothesis 2: Instruction in coordinate concepts would be more effective with the mixed presentations than with the pure presentations.

Hypothesis 3: Instruction in coordinate concepts would be more effective if the heuristic rule is present than if it is absent.

Hypothesis 4: Instruction in coordinate concepts would be more effective if practice items are present than if they are absent.

With one exception, the same hypotheses were predicted for the dependent variables of instructional time and test time. The exception was that instructional time for practice treatments would be longer than for no practice treatments.

Materials

The experiments presented a concept-classification task using four types of poetic meter: trochaic, iambic, dactylic, and anapestic. Typical definitions, examples and practice items are presented below.

DEFINITIONS (Simultaneous. The sequential treatments present one definition on a page.)

A TROCHAIC FOOT consists of a stressed syllable followed by an unstressed syllable.

TUM - ta

An IAMBIC FOOT consists of an unstressed syllable followed by a stressed syllable.

ta - TUM

etc.

EXAMPLES (Simultaneous)

TROCHAIC — Rich the treasure

Sweet the pleasure

IAMBIC — The curfew tolls

It tolls for thee

etc.

EXAMPLES (Sequential)

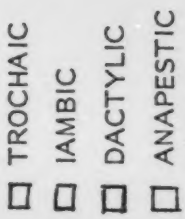
TROCHAIC — Rich the treasure

Sweet the pleasure

TROCHAIC — I a light canoe will build me

etc. — Like a yellow leaf in Autumn

PRACTICE (Simultaneous)



Hope is banished

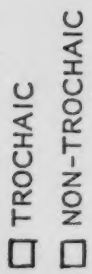
Joys are vanished

With vanished fears

The monarch nears

etc.

PRACTICE (Sequential)



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etc.

The materials for the treatment groups consisted of a prerequisite test, a time sheet, the instructional task, a time sheet, the posttest, a time sheet and a student posttest questionnaire, all of which were presented in a loose-leaf notebook. All components except the instructional task were the same for all treatment groups.

The prerequisites test assessed whether the students had studied poetic meter and if they were able to divide words into syllables and determine the stressed syllable.

Students were asked to record the current time on the time sheets as they progressed through the materials.

The instructional task presented the rules, examples, and practice items as designated by the treatment conditions. All treatment groups received the same twelve instances of each of the concepts. The no practice treatments received twelve examples. Practice treatments received six examples and six practice items with correct answer feedback. In the sequential treatments, twice as many practice items were given to provide a choice between examples and nonexamples. Each practice item was presented twice, once for classification as an example of one concept and once as a non-example of another concept. Thus, each treatment had the same number of unencountered instances and the same number of correct meter classifications for each concept.

The mixed simultaneous and sequential treatments received the same twelve instances. However, only two of these instances were presented with the rule.

The posttest consisted of a multiple-choice test requiring the student to classify unencountered instances of poetry in each type of poetic meter. Every instance in both the instructional task and the test was a pure instance of one of the four types of poetic meter (i.e., there were no mixed-meter lines or lines with an added or deleted syllable.)

The student questionnaires asked the student to rate 1) his level of interest in the lesson, 2) his level of effort and 3) how much he thought he learned from the lesson.

Procedure

A posttest only design was used. Treatments were randomly assigned within each class. Students completed the prerequisite test, recorded the

initial instructional time, worked through the instructional packet, recorded the final instructional time, completed the posttest, recorded the final test time and completed the student questionnaire.

Experiment 1

Treatments

Ten treatments were derived from a 2x2x2 completely crossed factorial design with two replicated treatment groups with the heuristic rule (see Figure 3). The heuristic rule was presented immediately after the four concept rules in both the simultaneous plus heuristic and mixed simultaneous plus heuristic treatments. In this experiment, the heuristic rule was not presented with any of the sequential treatments.

Subjects

Subjects for the experiment were 69 students from introductory psychology and English classes. Only students who had not studied poetic meter and were able to identify syllables and stress patterns were included in the analysis.

RESULTS OF EXPERIMENT I-A

Instructional Time

Table 1 shows the raw means, standard deviations, and number of students for the main and interaction effects for instructional time. The factorial analysis revealed significance on two main effects: practice, $F(1,61) = 30.00$ p .00005, and sequence, $F(1,61) = 5.094$, $p = .03$. There were no significant interaction effects.

Insert Table 1

The significance on practice indicated that the students spent less time studying the instructional materials if practice was absent than if practice was present. The significance on sequence indicates that the students spent less time on the instructional materials if the coordinate concepts were presented sequentially than if they were presented simultaneously.

No significant differences were found between pure and mixed sequences on instructional time.

Test Time

Table 2 shows the raw means, standard deviations, and number of students for the main and interaction effects on test time. The factorial analysis revealed one significant main effect, practice, $F(1,61) = 5.765$, $p = .02$, and one interaction effect, purity - practice, $F(1,61) = 3.342$, $p = .07$.

Insert Table 2

The significance on practice indicates that the students who received practice spent less time on test than those who received no practice. The significant interaction indicates that when practice was absent, students spent more time on the test given the mixed sequences than they did given the pure sequences. When practice was present, the reverse was true: the students spent less time on the test given the mixed sequences than they did given the pure sequences.

Posttest

Table 3 shows the raw means, standard deviations, and number of students for the main and interaction effects on posttest scores. The factorial analysis revealed significance on the three-way interaction effect, between practice, sequence, and purity, $F(1,61) = 5.004$, $p = .03$. There were no significant main effects.

Insert Table 3

The significance on the interaction effect indicates 1) with sequential-no practice treatments, a mixed sequence was more effective than a pure sequence, and 2) in sequential-practice treatments, a pure sequence is more effective than a mixed sequence. The two highest cell means were mixed sequential with practice absent and pure sequential with practice present. The two lowest cell

means were pure simultaneous with practice present and mixed sequential with practice present.

Interest

There were no significant main or interaction effects on interest scores.

RESULTS OF EXPERIMENT I-B

To analyze the effects of the heuristic on instructional time, test time, and posttest scores, 2x2 factorial analysis of variance and analysis of covariance were performed with the main factors being mixed versus pure simultaneous presentation and presence or absence of a heuristic rule. The covariate was the student's rating of his effort to learn the task measured on a scale from 1 to 7.

Table 4 shows the F-ratios for the significance of the relationship of the covariate, student effort to learn the task, with each of the four dependent variables and the homogeneity of slopes for each dependent variable. On the basis of these results, the covariate was used with posttest and interest scores.

Insert Table 4

Instructional Time

There were no significant main or interaction effects on instructional time.

Test Time

There were no significant main or interaction effects on test time.

Posttest Scores

Table 5 shows the adjusted means, standard deviations, and number of students for the main and interaction effects on posttest scores. The analysis of covariance revealed significance on one main effect: heuristic, $F(1,29) = 3.775$, $p = .06$.

Insert Table 5

The significance on heuristic indicates that posttest scores were higher if the heuristic was presented than if it was not.

Interest Scores

Table 6 shows the adjusted means, standard deviations, and number of students for the main and interaction effects on interest scores. The analysis of covariance revealed significance on one main effect: heuristic, $F(1,29) = 2.961$, p .10.

METHODS OF EXPERIMENT II

The significant effects of the heuristic on posttest performance suggested the need for a further experiment to test the heuristic in simultaneous, sequential, pure, and mixed sequences. In Experiment II, a 2^4 completely crossed factorial design compared the effects of simultaneous and sequential sequences (first factor), pure and mixed sequences (second factor), presence or absence of the heuristic rule (third factor) and the sex of the student (fourth factor) see Figure 4. The dependent variables were instructional time, test time, and posttest performance.

Insert Figure 4 about here

The simultaneous, sequential, pure, and mixed treatments have been described previously. In Experiment II, all treatments included practice items as designated by the treatment. The heuristic was presented at the end of the instructional task (after the student had completed all rules, examples, and practice items) and just prior to the test.

Subjects

Subjects for the experiment were 100 students from introductory psychology classes. Only students who had not studied poetry meter and were able to identify syllables and stress patterns were included in the analysis.

RESULTS OF EXPERIMENT II

The results were analyzed with the analysis of covariance and analysis of variance. Table 7 presents the results of significance and homogeneity of the covariates for each dependent variables.

Insert Table 7 about here

The analysis of covariance, in general, showed more highly significant effects than the analysis of variance. However, some significant effects from the analysis of variance did not show up with the analysis of covariance. These significant analysis of variance results will also be reported.

Instructional Time

Table 8 presents the adjusted means, standard deviations, and number of students for the main and interaction effects on instructional time. The analysis of covariance (covariates=student GPA and prerequisites test score) revealed significant interactions between purity and sex $F(1,82)=10.09$, $p=.002$, between heuristic, sequence, and purity $F(1,82)= 7.08$, $p=.01$, and between heuristic, purity, and sex $F(1,82)=3.33$, $p=.07$. The analysis of variance also revealed a significant main effect of sex $F(1,84)=3.17$, $p=.08$.

Insert Table 8 about here

The main effect of sex indicates that females spend less time on the lesson than males. The interaction between purity and sex (see Figure 5) shows that males spend less time on pure sequences than on mixed sequences. Females spend less time on mixed sequences than on pure sequences. The interaction between purity, heuristic and sex (see Figure 5) indicates that males spend

the least time on a pure-heuristic treatment and the most time on a mixed-heuristic treatment. Females spend the least time on both a mixed-no heuristic and mixed heuristic treatments and the most time on a pure-heuristic treatment.

Insert Figure 5 about here

The interaction between sequence, purity and heuristic (see Figure 5) indicates that with a simultaneous presentation the pure-no heuristic and mixed-heuristic treatments took less instructional time while the pure-heuristic and mixed-no heuristic treatments took more instructional time. Given a sequential presentation the pure-heuristic and mixed-no heuristic treatments took less instructional time while the pure-heuristic and mixed-no heuristic took more instructional time.

Test Time

Table 9 presents the adjusted means, standard deviations and number of students for the main and interaction effects on test time.

An analysis of covariance (covariate=effort on test) revealed two signficant main effects, heuristic $F(1,83)=4.58$, $p=.04$, and sex $F(1,83)=4.02$, $p=.05$. One second order interaction was significant between purity and sex $F(1,83)=3.90$, $p=.05$. The analysis of variance also showed a significant third order interaction between heuristic, sequence and purity $F(1,84)=4.48$, $p=.04$.

Insert Figure 9 about here

The results indicate that 1) males take longer on the test than females and 2)students with the heuristic take longer than students without it. The interaction between purity and sex (see Figure 6) shows that males take longer on the test given mixed sequences than pure sequences, females take less time on the test given mixed sequences than pure sequences. The three way interaction (see Figure 6) shows that the heuristic requires more time on the test for all treatments except the simultaneous-mixed in which it requires less time. Given a sequential sequence the mixed-heuristic treatment has the longest test time. Given a simultaneous sequence the pure-heuristic takes the longest test time.

Insert Figure 6 about here

Posttest Scores

Table 10 presents the adjusted means, standard deviations and number of students for the main and interaction effects on posttest scores. The analysis of covariance (covariates=student GPA, prerequisite test score, effort on test, affect toward content) revealed significance on two main effects: heuristic $F(1,80)=7.04$, $p=.02$ and purity $F(1,80)=5.32$, $p=.02$. a first order interaction was significant between heuristic and sex $F(1,80)=3.18$, $p=.08$. The three way interaction between heuristic, sequence, and purity was also significant $F(1,80)=4.06$, $p=.03$.

Insert Table 10 about here

The results show that the heuristic signficantly improves students' posttest scores. The interactions of heuristic and sex (see Figure 7) indicates that the heuristic is more effective in improving these scores for males than for females. The mixed sequences are more effective than pure sequences for all treatments except the sequential heuristic treatments in which the pure sequence is slightly more effective than the mixed sequence. The most effective treatment, overall, was the simultaneous-mixed-heuristic treatment (see Figure 7). The significant interaction between sequence, purity, and heuristic shows that the heuristic is equally effective for both sequential-pure and sequential-mixed sequences. However, the heuristic is considerably more effective for simultaneous-mixed sequences than for simultaneous-pure sequences (see Figure 7).

Table 11 shows a comparison table of the treatment conditions and their results on the three dependent variables, instructional time, test time and posttest scores. This table shows that the simultaneous-mixed-heuristic is the optimum treatment. It requires less instructional time, less test time, and students' performance is very high.

DISCUSSION

The results from these experiments suggest the following conclusions:

1) The effects of simultaneous and sequential treatments on instructional time are equivocal. Experiment I-A indicates

that sequential treatments require less time than simultaneous sequences. The results from Experiment II fail to support this finding.

2) The presence of practice items increases the instructional time, however, when the number of instructional instances is held constant practice does not affect test time or posttest scores.

3) Experiment I-A indicates that a sequential presentation with practice is more effective for pure than mixed sequences. The results from Experiment II fail to support this finding.

4) Females require less instructional time and less test time than males. Posttest scores for males and females are nearly equivalent.

5) Males require more instructional time and test time on mixed than pure sequences. Females require less instructional time and test time on mixed than pure sequences.

6) The heuristic increases test time and student posttest scores and interest in the lesson. The increase in posttest scores is more for males than females.

7) Mixed sequences are generally more effective than pure sequences.

8) The optimum treatment in these experiments is the simultaneous-mixed-heuristic. This treatment requires less instructional

time, less test time and student posttest scores are much higher than with any other treatment.

A possible explanation for the superiority of the simultaneous-mixed-heuristic treatment is that: 1) the simultaneous presentation allows the student to compare and contrast the four coordinate concepts, 2) the mixed presentation allows the student to integrate the rule to two specific examples, and 3) the heuristic provides a sorting or general classification rule for the four coordinate concepts.

A possible explanation for the low performanceeof the simultaneous-pure-heuristic treatment is that without an integrated rule and example combination students find it difficult to learn the four concepts if they are presented at the same time.

The significant higher order interactions from Experiment II are rather difficult to interprete. Two plausible explanations exist for the large number of higher order interactions. First, the interactions are an artifact due to 1) the small and unequal cell sizes, and 2) there is high within cell variabliity. Second, the interactions are true effects which result from differing response values depending on the levels of the other two to three factors. In experiment II, the three way interactions are based on unequal and rather small cell sizes ($n<15$), but have rather similar standard deviations. A replication of the study with larger and equal cell sizes would help to establish whether the high order interactions are true effects or experimental artifacts.

These experiments have suggested the need for several research studies, such as, 1) What are the effects os placing the geuristic at the beginning, middle, or end of the instructional lesson?,,2)What are the classification errors that students make given differing instructional sequences?,

3) How do the students actually use the heuristic rule in processing the lesson information and in responding to the test?, 4) What are the reasons the the differences in student scores on the simultaneous-mixed-heuristic treatment and the simultaneous-pure -heuristic treatment?, and 5) What are the effects of differing proportions pf examples and practice items in simultaneous and sequential sequences?

FIGURE 1: A Concept Taxonomy

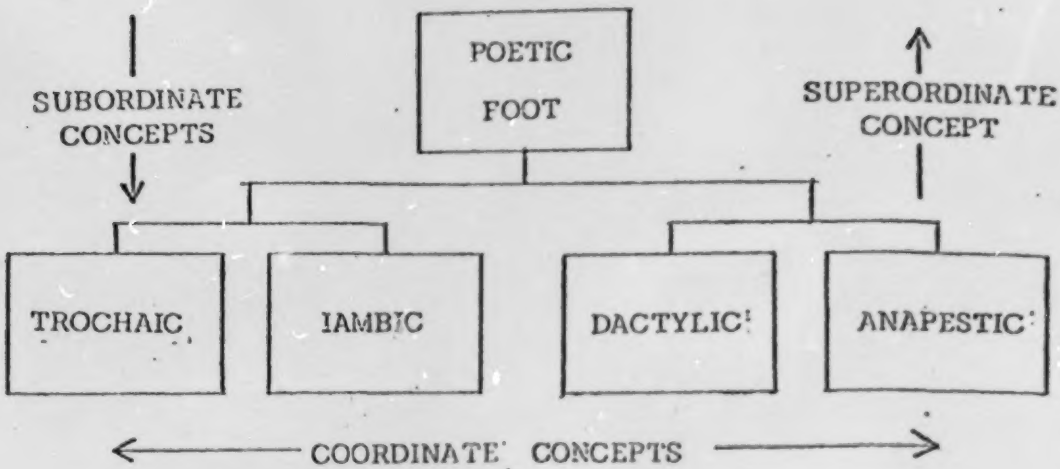
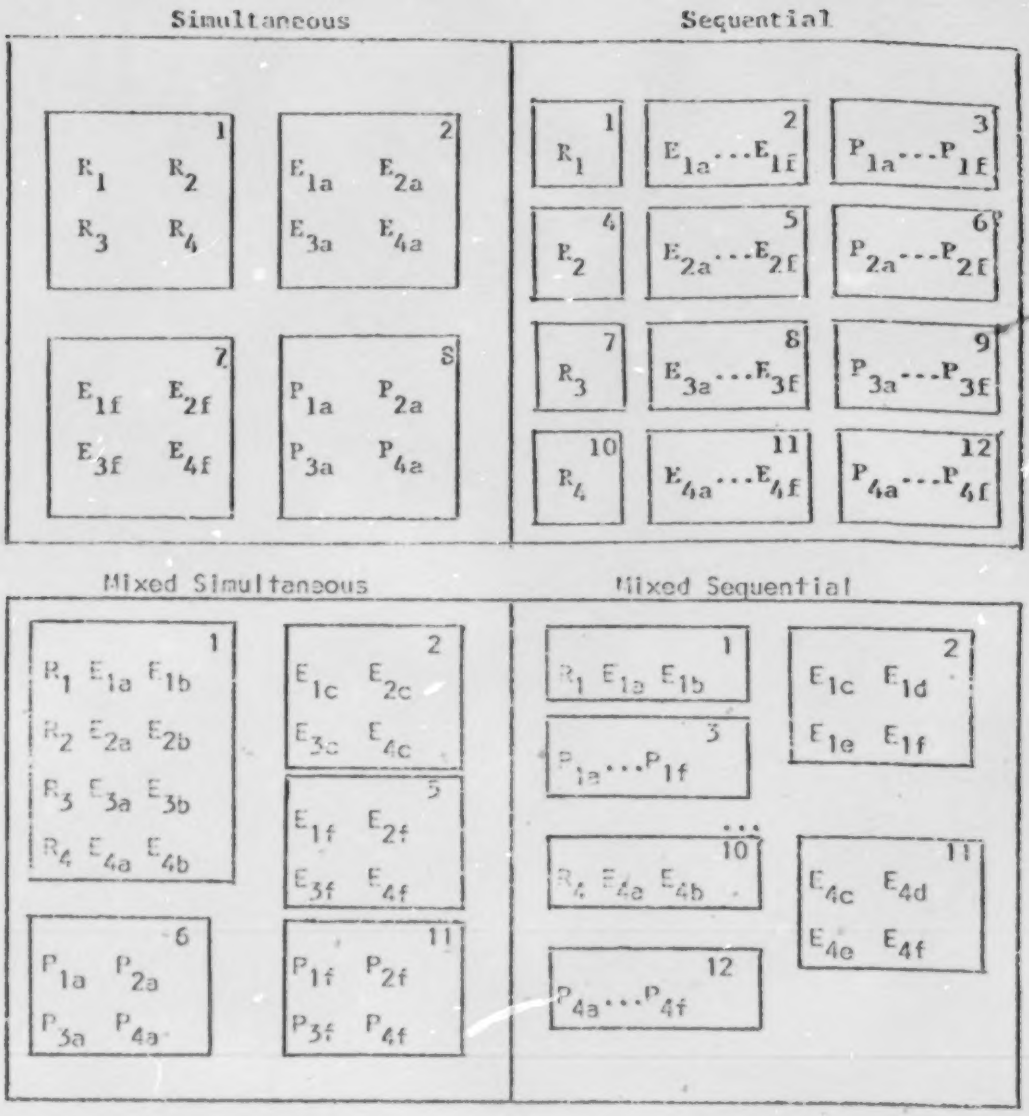


Figure 1.
The concept poetic foot is superordinate to each of the particular kinds of feet. The concept iambic is subordinate to the concept poetic foot. The concepts iambic, trochaic, dactylic, and anapestic are coordinate.



Small squares -- one page of instruction.
R -- Rules (expository generalities).
E -- Examples (expository instances).
P -- Practice items (inquisitory instances) with correct-answer feedback on the reverse side of the page.
1-4 -- The four concepts (trochaic, iambic, dactylic, and anapestic).
a-f -- The different instances. (Note: there were six instances for each concept, with one instance on each of six different levels of difficulty. All instances on the same level were matched with each other as much as possible, and instances on different levels were as divergent as possible along the continuum of difficulty.
Number in upper right-hand corner of each page -- page number in that treatment.

Figure 7. Schematic diagram of the sequencing in each of the four primary treatments.

Figure 3

EXPERIMENTAL DESIGN FOR EXPERIMENT I

Sequence	Simultaneous		Sequential	
Purity	Pure	Mixed	Pure	Mixed
No Practice				
Practice				
Heuristic+ No Practice				

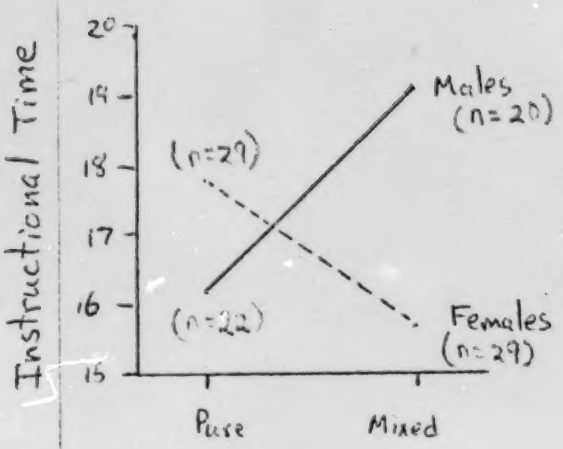
Figure 4

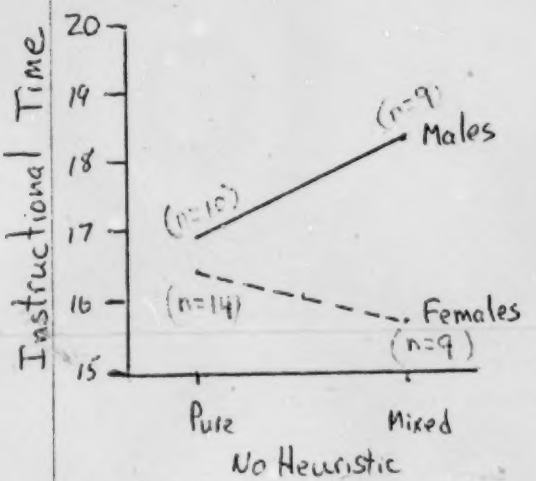
EXPERIMENTAL DESIGN FOR EXPERIMENT II

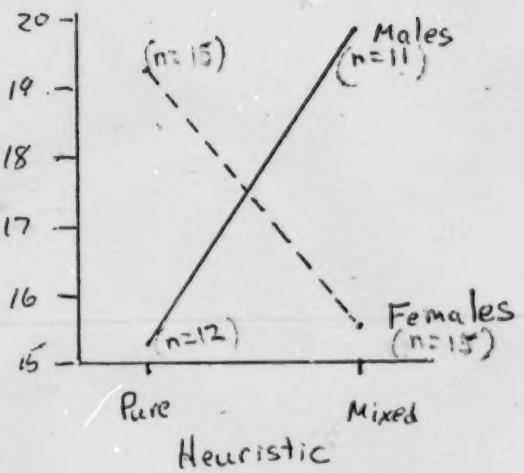
Sequence	Simultaneous				Sequential			
Purity	Pure		Mixed		Pure		Mixed	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
No Heuristic								
Heuristic								

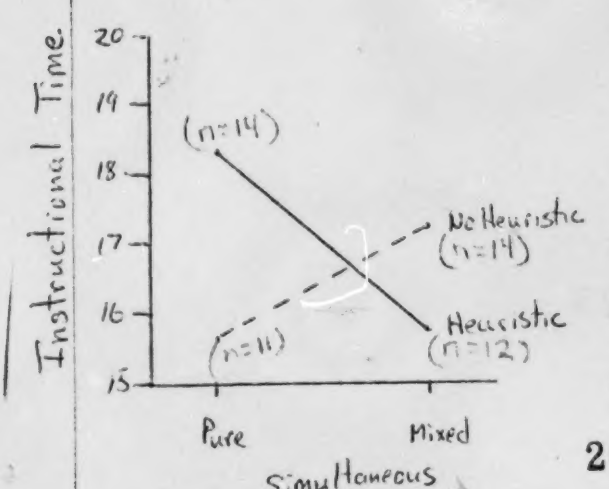
Figure 5

Graphs of Significant interactions on Instructional Time Exp. II









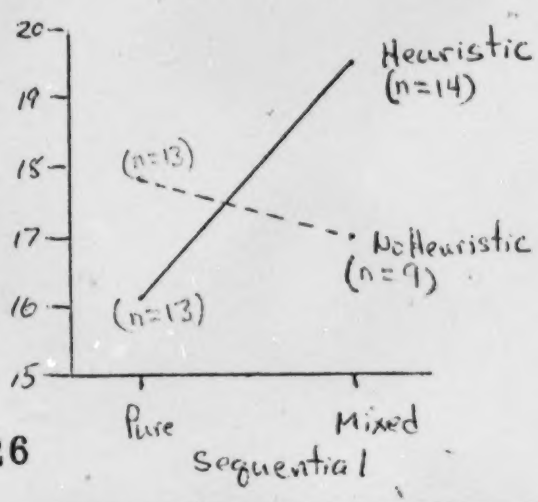
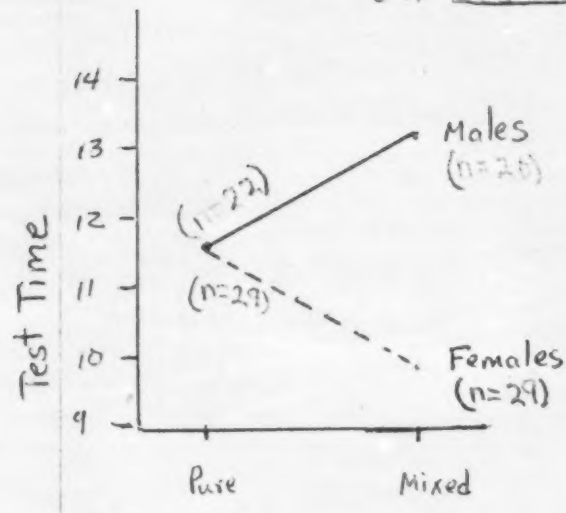
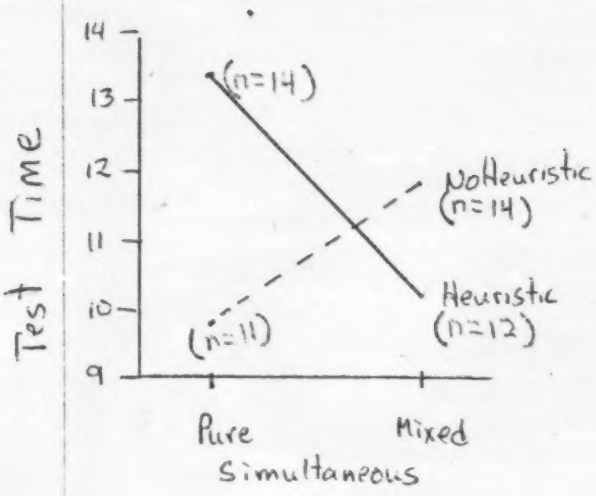
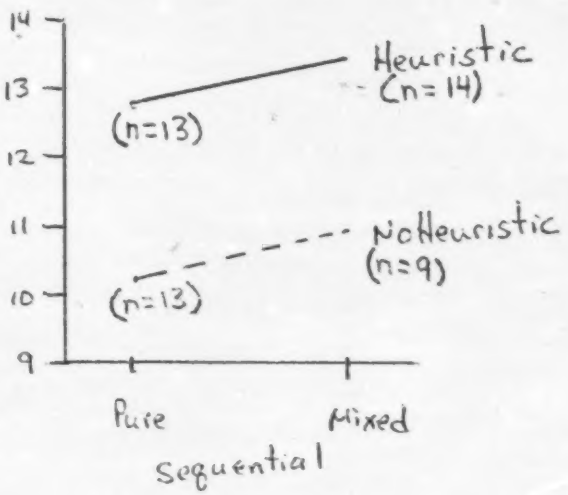


Figure 6

Graphs of significant interactions on test time Exp. II.







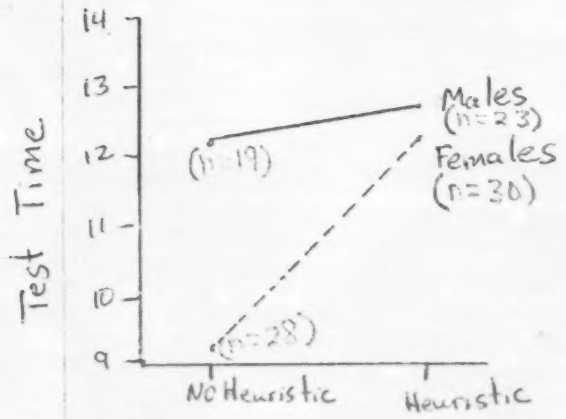


Figure 7

Graphs of significant interactions on post test scores Exp II

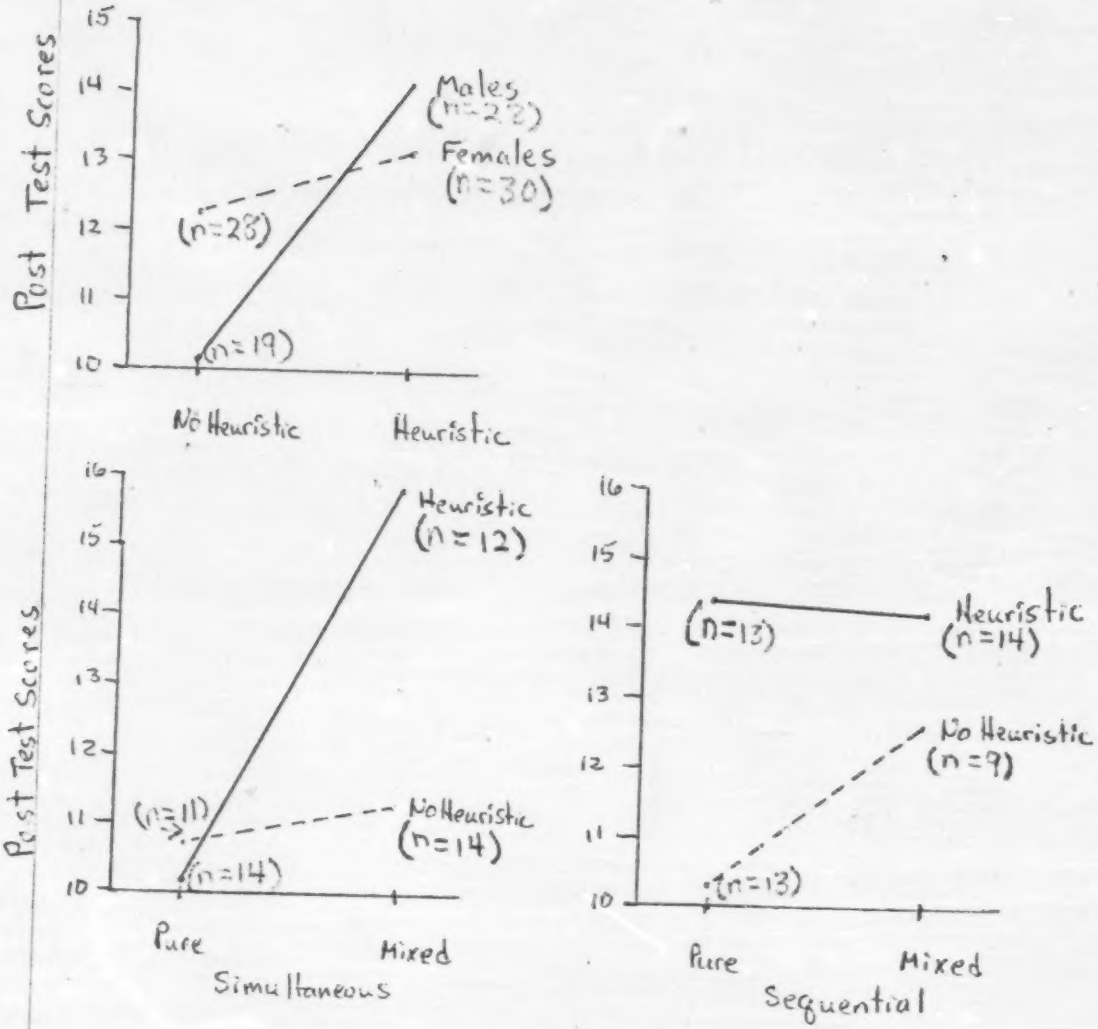


Table 1

The means (standard deviations), and number of students for the main and interaction effects on instructional time Measured in Minutes

Simultaneous	Sequential
14.33 (0.64) n = 33	12.33 (0.61) n = 36
Pure	Mixed
13.33 (0.64) n=33	13.33 (0.61) n = 36
No Practice	Practice
10.99 (0.63) n = 34	15.67 (0.62) n = 35

Simultaneous - Pure	Simultaneous - Mixed	Sequential - Pure	Sequential - Mixed
13.99 (0.94) n = 15	14.67 (0.86) n = 18	12.67 (0.86) n = 18	12.00 (0.86) n = 18
Simultaneous - No Practice	Simultaneous - Practice	Sequential - No Practice	Sequential - Practice
12.21 (0.92) n = 16	16.45 (0.89) n = 17	9.78 (0.86) n = 18	14.89 (0.86) n = 18
Pure - No Practice	Pure - Practice	Mixed - No Practice	Mixed - Practice
10.48 (0.92) n = 16	16.17 (0.89) n = 17	11.50 (0.86) n = 18	15.17 (0.86) n = 18

Sim-Pure-NoP	Sim-Pure-P	Sim-Mix-NoP	Sim-Mix-P	Seq-Pure-NoP	Seq-Pure-P	Seq-Mix-NoP	Seq-Mix-P
11.86 (1.38) n = 7	16.13 (1.29) n = 8	12.56 (1.22) n = 9	16.78(1.22) n = 9	9.11 (1.22) n = 9	16.22 (1.22) n = 9	10.44 (1.22) n = 9	13.56 (1.22) n = 9

LEGEND

Sim = Simultaneous
Seq = Sequential
Mix = Mixed
P = Practice

Table 2

The means (standard deviations), and number of students for the main and interaction effects on test time

Measured in Minutes

Simultaneous	Sequential
8.93 (0.50) n = 33	8.80 (0.48) n = 36
Pure	**Mixed**
8.99 (0.50) n = 33	8.75 (0.48) n = 36
No Practice	**Practice**
9.71 (0.50) n = 34	8.03 (0.49) n = 35

Simultaneous - Pure	Simultaneous - Mixed	Sequential - Pure	Sequential - Mixed
8.98 (0.75) n = 15	8.89 (0.68) n = 18	9.00 (0.68) n = 18	8.61 (0.68) n = 18
Simultaneous - No Practice	**Simultaneous - Practice**	**Sequential - No Practice**	**Sequential - Practice**
9.86 (0.73) n = 16	8.01 (0.70) n = 17	9.56 (0.68) n = 18	8.06 (0.68) n = 18
Pure - No Practice	**Pure - Practice**	**Mixed - No Practice**	**Mixed - Practice**
9.19 (0.73) n = 16	8.79 (0.70) n = 17	10.22 (0.68) n = 18	7.28 (0.68) n = 18

Sim-Pure-NoP	Sim-Pure-P	Sim-Mix-NoP	Sim-Mix-P	Seq-Pure-NoP	Seq-Pure-P	Seq-Mix-NoP	Seq-Mix-P
9.71 (1.09) n = 7	8.25 (1.02) n = 8	10.0 (0.96) n = 9	7.78 (0.96) n = 9	8.67 (0.96) n = 9	9.33 (0.96) n = 9	10.44 (0.96) n = 9	6.78 (0.96) n = 9

LEGEND

Sim = Simultaneous
Seq = Sequential
Mix = Mixed
P = Practice

Table 3

The means (standard deviations), and number of students for the main and interaction effects on posttest scores

Simultaneous				Sequential			
9.75 (0.89) n = 33				11.11 (0.84) n = 36			
Pure				Mixed			
10.33 (0.89) n = 33				10.53 (0.84) n = 36			
No Practice				Practice			
10.86 (0.87) n = 34				10.03 (0.86) n = 35			
Simultaneous - Pure		Simultaneous - Mixed		Sequential - Pure		Sequential - Mixed	
9.49 (1.31) n = 15		10.00 (1.19) n = 18		11.17 (1.19) n = 18		11.06 (1.99) n = 18	
Simultaneous - No Practice		Simultaneous - Practice		Sequential - No Practice		Sequential - Practice	
10.10 (1.28) n = 16		9.40 (1.23) n = 17		11.56 (1.19) n = 18		10.67 (1.19) n = 18	
Pure - No Practice		Pure - Practice		Mixed - No Practice		Mixed - Practice	
10.37 (1.28) n = 16		10.29 (0.70) n = 17		11.28 (1.19) n = 18		9.78 (1.19) n = 18	
Sim-Pure-NoP	Sim-Pure-P	Sim-Mix-NoP	Sim-Mix-P	Seq-Pure-NoP	Seq-Pure-P	Seq-Mix-NoP	Seq-Mix-P
10.86 (1.91) n = 7	8.13 (1.79) n = 8	9.33 (1.69) n = 9	10.67(1.69) n = 9	9.89 (1.69) n = 9	12.44(1.69) n = 9	13.22 (1.69) n = 9	8.89 (1.69 n = 9

LEGEND

Sim = Simultaneous
Seq = Sequential
Mix = Mixed
P = Practice

Table 4

Significance and Homogeneity of the Covariate
for Each Dependent Variable

	Instructional Time	Test Time	Posttest	Interest
Hom F(3,26)	0.468	0.213	0.189	1.858
Sig F(1,29)	0.040 p = .84	0.024 p = .88	7.876 p = .009	5.397 p = .03

Note: $F_{.05}$ (3,26) = 2.98

Key:

Sig = Significance of the relationship of the covariate with each dependent variable.

Hom = Homogeneity of slopes of the covariate within the cell structure at the experimental design.

Table 5

Adjusted Means, (Standard Deviations), and Number of Students for the Main and Interaction Effects on Posttest Scores

	Pure	Mixed	Totals
Heuristic Absent	14.77 (2.20) n = 7	14.24 (2.16) n = 9	14.37 (1.93) n = 16
Heuristic Present	15.24 (2.02) n = 9	18.49 (2.34) n = 9	17.68 (2.06) n = 18
Totals	15.01 (1.78) n = 16	16.36 (1.98) n = 18	

Table 6

Adjusted Means, (Standard Deviations), and Number of Students for the Main and Interaction Effects on Interest Scores

	Pure	Mixed	Totals
Heuristic Absent	3.07 (0.73) n = 7	2.81 (0.72) n = 9	2.87 (0.64) n = 16
Heuristic Present	4.85 (0.67) n = 9	3.51 (0.78) n = 9	3.84 (0.68) n = 18
Totals	3.96 (0.59) n = 16	3.16 (0.66) n = 18	

Table 7

Significance and Homogeneity of the
Covariates for Each Dependent Variable

			DEPENDENT VARIABLES		
			Instructional Time	Test Time	Post Test
COVARIATES	GPA	Sig	F(1,82)=2.96	---	F(1,80)=3.69
		Hom	F(15,67)=1.38	---	F(15,65)=1.78
	PREREQ	Sig	F(1,82)=6.46	---	F(1,80)=9.84
		Hom	F(15,67)=.69	---	F(15,65)=1.10
	Effort on Treatment	Sig	---	---	---
		Hom	---	---	---
	Effort on Test	Sig	---	F(1,83)=3.79	F(1,80)=13.45
		Hom	---	F(15,68)=1.32	F(15,65)=1.57
	Affect on Content	Sig	---	---	F(1,80)=3.38
		Hom	---	---	F(15,65)=.83

$F_{.05}(15,100)=2.12$

Key Sig=Significance of the covariate with each dependent variable.
Hom=Homogeneity of slopes for the covariate for all effects and interactions in the experimental design.
--- intecates that the covariate was either not significant or homogeneous with the other covariates in the model.

Table 8

The means, (standard deviations); and number of students for the main and interaction effects on instructional time measured in minutes

Simultaneous 16.71 (0.55) n=51	Sequential 17.60 (0.57) n=49
Pure 16.98 (0.56) n=51	Mixed 17.32 (0.57) n=49
No Heuristic 16.89 (0.60) n=47	Heuristic 17.42 (0.57) n=53
Males 17.60 (0.61) n=42	Females 16.70 (0.52) n=58

Sim-Pure 16.99 (0.80) n=25	Sim-Mix 16.42 (0.77) n=26	Seq-Pure 16.98 (0.79) n=26	Seq-Mix 18.22 (0.83) n=23
Sim-NoH 17.80 (0.81) n= 27	Sim-H 17.04 (0.77) n=26	Seq-NoH 17.40 (0.84) n=22	Seq-H 17.80 (0.81) n=27
Pure-NoH 6.73 (0.82) n=24	Pure-H 17.24 (0.81) n=27	Mix-NoH 17.04 (0.84) n=23	Mix-H 17.60 (0.77) n=26
Pure-M 16.15 (0.87) n=22	Pure-F 17.81 (0.74) n=29	Mix-M 19.05 (0.86) n=20	Mix-F 15.59 (0.74) n=29
Sim-Pure-NoH 15.60 (1.21) n=11	Sim-Pure-H 8.37 (1.07) n=14	Sim-Mix-NoH 17.14 (1.08) n=14	Sim-Mix-H 15.71 (1.11) n=12
Seq-Pure-NoH 17.86 (1.07) n=13	Seq-Pure-H 16.10 (1.20) n=13	Seq-Mix-NoH 16.95 (1.28) n=9	Seq-Mix-H 19.49 (1.06) n=14
Pure-NoH-M 16.98 (1.24) n=10	Pure-NoH-F 16.48 (1.06) n=14	Pure-H-M 15.33 (1.25) n=12	Pure-H-F 19.14 (1.05) n=15
Mix-NoH-M 18.40 (1.28) n=9	Mix-NoH-F 15.69 (1.08) n=11	Mix-H-M 19.71 (1.16) n=11	M-H-F 15.50 (1.01) n=15

Legend: Sim=Simultaneous Seq=Sequential Mix=Mixed NoH=No H-Heuristic

Table 9

The means (standard deviations), and number of students
for the main and interaction effects on test time measured in minutes

Simultaneous 11.26(0.57)n=51			Sequential 11.84(0.59)n=49
Pure 11.54(0.57)n=51			Mixed 11.55(0.58)n=49
No Heuristic 10.66(0.60)n=47			Heuristic 12.44(0.57)n=53
Male 12.37(0.62)n=42			Female 10.73(0.53)n=58
Sim-Pure 11.61(0.82)n=25	Sim-Mix 10.90(0.79)n=26	Seq-Pure 11.48(0.82)n=26	Seq-Mix 12.20(0.86)n=23
Sim-NoH 10.74(0.84)n=25	Sim-H 11.77(0.78)n=26	Seq-NoH 10.57(0.86)n=22	Seq-H 13.11(0.82)n=27
Pure-NoH 9.99(0.83)n=24	Pure-H 13.10(0.81)n=27	Mix-NoH 11.33(0.86)n=23	Mix-H 11.78(0.79)n=26
Pure-M 11.54(0.89)n=22	Pure-F 11.55(0.74)n=29	Mix-M 13.20(0.89)n=20	Mix-F 9.91(0.75)n=29
M-NoH 12.08(0.92)n=19	M-H 12.66(0.86)n=23	F-No H 9.24(0.76)n=28	F-H 12.22(0.73)n=30
Sim-Pure-NoH 9.77(1.23)n=11	Sim-Pure-H 13.45(1.06)n=14	Sim-Mix-NoH 11.72(1.12)n=14	Sim-Mix-H 10.09(1.14)n=12
Seq-Pure-NoH 10.20(1.09)n=13	Seq-Pure-H 12.75(1.24)n=13	Seq-Mix-NoH 10.94(1.32)n=9	Seq-Mix-H 13.47(1.10)n=14

Legend: Sim=Simultaneous Seq=Sequential Mix=Mixed NoH=No Heuristic H=Heuristic

Table 10

The means, (standard deviations) and number of students for the main and interaction effects on posttest scores

Simultaneous 11.96(0.60)n=51			Sequential 12.88(0.62)n=49
Pure 11.38(0.60)n=51			Mixed 13.46(0.61)n=49
No Heuristic 11.19(0.65)n=47			Heuristic 13.65(0.61)n=53
Male 12.16(0.66)n=42			Female 12.68(0.56)n=58
Sim-Pure 10.39(0.87)n=25	Sim-Mixed 13.52(0.83)n=26	Seq-Pure 12.37(0.86)n=26	Seq-Mixed 13.40(0.90)n=23
Sim-NoH 10.96(0.89)n=25	Sim-H 12.95(0.83)n=26	Seq-NoH 11.42(0.91)n=22	Seq-H 14.35(0.88)n=27
Pure-NoH 10.49(0.89)n=24	Pure-H 12.27(0.88)n=27	Mix-NoH 11.89(0.91)n=23	Mix-H 15.03(0.84)n=26
NoH-M 10.16(0.97)n=19	H-M 14.17(0.95)n=23	NoH-F 12.23(0.83)n=28	H-F 13.13(0.78)n=30
Sim-Pure-NoH 10.69(1.31)n=11	Sim-Pure-H 10.09(1.17)n=14	Sim-Mix-NoH 11.24(1.19)n=14	Sim-Mix-H 15.81(1.20)n=12
Seq-Pure-NoH 10.30(1.16)n=13	Seq-Pure-H 14.45(1.32)n=13	Seq-Mix-NoH 12.55(1.39)n=9	Seq-Mix-H 14.25(1.16)n=14

Legend: Sim=Simultaneous Seq=Sequential Mix=Mixed NoH=No Heuristic H=Heuristic

Table 11

The adjusted cell means, (standard deviations), and number of students (summed across sex) for instructional time(IT), test time(TT), and posttest scores(PT)

		Sequential		Simultaneous	
		Pure	Mixed	Pure	Mixed
No Heuristic	IT	17.86(1.07)	16.95(1.28)	15.60(1.21)	17.14(1.08)
	TT	10.20(1.09)	10.94(1.32)	9.77(1.23)	11.72(1.12)
	PT	10.30(1.63) n=13	12.55(1.39) n=9	10.69(1.31) n=11	11.24(1.19) n=14
Heuristic	IT	16.10(1.20)	19.49(1.06)	18.37(1.07)	15.71(1.11)
	TT	12.75(1.24)	13.47(1.10)	13.45(1.06)	10.09(1.14)
	PT	14.45(1.33) n=13	14.25(1.16) n=14	10.09(1.17) n=14	15.81(1.20) n=12

Legend: IT=Instructional Time
TT=Test Time
PT=Posttest Score

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